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CERL'S SPORTING AMMUNITION TESTING FACILITY

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Canadian Explosives Research Laboratory

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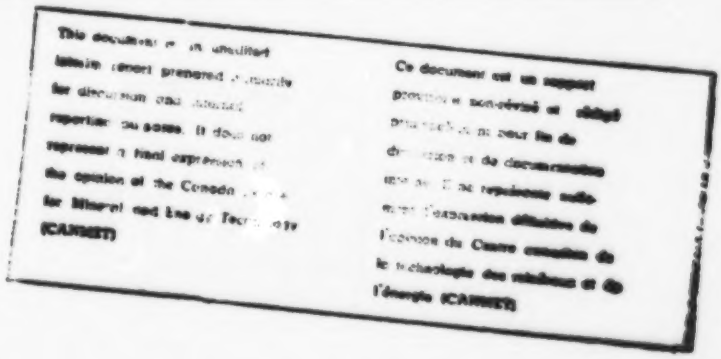

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MICROMEDIA

CERL'S SPORTING AMMUNITION TESTING FACILITY

by

E. Contestabile*, R.R. Vandebeek**, and T.R. Craig***

ABSTRACT

This report describes the sporting ammunition testing facilities at the Canadian Explosives Research Laboratory (CERL). The facilities described herein are those used to determine if the items in this category can be recommended for authorization under the Canada Explosives Act.

KEYWORDS: Bullet velocity, chamber pressure, Abel Heat test, primer heat test, comminution test.

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INSTALLATION DU LCRE POUR LE CONTRÔLE DES MUNITIONS UTILISÉES POUR LE SPORT

par

E. Contestabile *, R.R. Vandebeek**, et T.R. Craig***

RÉSUMÉ

Les auteurs donnent une description des installations servant à vérifier la stabilité des munitions utilisées pour le sport au Laboratoire canadien de recherche sur les explosifs (LCRE). Les installations dont ce rapport fait état sont utilisées pour déterminer s'il est possible de recommander que les articles, qui font partie d'une catégorie déterminée, soient certifiés en vertu de la Loi canadienne sur les explosifs.

Mots-clé : vitesse de la balle, pression de la chambre, épreuve de stabilité thermique Abel, vérification de l'amorce-détonateur, essai de fragmentation.

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TABLE OF CONTENTS

	Page
ABSTRACT	i
RÉSUMÉ	ii
INTRODUCTION	1
TESTS PERFORMED AT CERL	1
BULLET VELOCITY AND CHAMBER PRESSURE MEASUREMENTS	1
UN TEST 4 (a)	5
ABEL HEAT TEST	6
PRIMER HEAT TEST	8
COMMUNICATION TEST	9

FIGURES

No.		
1.	Complete Universal Receiver Mounted On A Concrete Base	2
2.	Typical Barrel With Pressure Transducer	2
3.	Equipment Used To Record Chamber Pressure And Bullet Velocity	3
4.	Cross-Section of Bullet Detectors	3
5.	Bullet Detectors Positioned Ahead Of The Bullet Deflectors And Underneath The Light Source	4
6.	Velocity Measuring System In The Range	4
7.	Location Of Test Components	5
8.	Test Configuration For The Abel Heat Test	8
9.	Pipe Container For The Primer Heat Test	9
10.	Sample With Initiating Heater Coil Installed	10
11.	Sample Placed In The Communication Test Container	10

INTRODUCTION

The Canadian Explosives Research Laboratory, (CERL), tests and recommends for authorization, to the Chief Inspector of Explosives, any item that falls under the Ammunition Class of the Canada Explosives Act. Specifically, CERL performs tests on any sporting ammunition manufactured and/or sold in Canada.

Basically, both the package and the item must conform to some established standard. For example, it is required to determine the stability of the propellant and primer, and the projectile velocity and the chamber pressure of sporting ammunition. The ballistic properties plus other physical dimensions of the ammunition must also conform to recognized standards within the industry.

TESTS PERFORMED AT CERL

Before any tests on samples are initiated, the operator must be familiar and must comply with the safety guidelines for the building where the tests are performed.

When the sample is first received, the manufacturer's and/or submittor's name and address are recorded. The purpose for the submission is recorded and it is assigned a number by the Chief Inspector of Explosives (CIE number), at the Explosives Branch. The sample is locked in a steel cabinet in Building 14.

Testing begins by fully describing the size and material from which the shipping and/or inner containers are made. The shipping container's label must include such items as class, lot number, weight, and any other markings. The inner container's label must include more specific items such as manufacturer and/or distributor, lot number, calibre, safety warnings, and whether the ammunition consists of reloads. All container labels must also confora to the bilingual language requirements.

The next step is to describe the contents. For shotshells, the base and overall lengths are measured and recorded.

A series of tests to determine compliance with certain industry safety standards can now be performed. The tests are:

A. Bullet velocity and chamber pressure measurements
B. UN Test series 4(a)
C. Abel heat test
D. Primer heat test
E. Communication test

To prepare for some of these tests, it is required to disassemble the sample. The bullet from a particular round can be weighed and described once it has been removed with the use of a bullet puller. Once this is done, the propellant can be simply poured out for weighing and identification. The primer is left in the case for the heat test.

It is a little more difficult to disassemble a shotshell. The case should be cut very close to the top, making sure that none of the shot is spilled. The shot can now be poured in a container for the purpose of description, weighing, and counting. Once this is done, the wad can be removed and the propellant poured out. The wad is measured and described and the propellant is weighed and identified. Again, the primer is left in the base for the heat test.

BULLET VELOCITY AND CHAMBER PRESSURE MEASUREMENTS

CERL's history of performing physical tests began with the use of a universal receiver that allowed pressure measurements to be determined via a copper crusher. Potter, Model 601 photoelectric screens and Model 471 counter chronographs (1), were used to measure the bullet velocity.

The system was later modified to accept a quartz/integral piston, pressure transducer. The transducer was located in a hole leading to the chamber area of the barrel. In using this method, it was necessary to drill a small hole in the cartridge case of the ammunition being tested. This hole was made to coincide with that in the chamber so that when the round was fired, the pressure developed in the cartridge would be detected by the pressure transducer. At this time, the chronograph was replaced with a solid state digital counter, to display the transit time of the bullet from the first photoelectric screen to the next.

In the most recent modification, the universal receiver and projectile velocity measuring system were completely redesigned to produce equipment that was sturdy, dependable and allowed adaption to existing testing methods used by the industry. The universal receiver was manufactured (2) by copying the breech end of a German 37 mm Pak (single-shot, anti-tank gun), manufactured by Rheinemetall in 1935. A detailed description of this apparatus is given in reference (3). Figure 1 shows the complete universal receiver assembly. It is mounted on a concrete base. A keyed, electrically actuated, solenoid valve fires the receiver via a pneumatic cylinder. This configuration allows the firing to be performed from a remote location away from the blast and fumes.

Different calibre barrels were manufactured as suggested by SAAMI (Sporting Arms and Ammunition Manufacturers' Institute) (4), an example of which is shown in Fig. 2. They are easily installed in the receiver and are held in place by a retaining nut. Due to their length, the rifle barrels are also supported near the muzzle end to increase the rigidity of the system. Different firing pins were also designed and manufactured and are easily interchangeable when the requirement arises. For example, different pins are used for testing rifle and handgun ammunition.

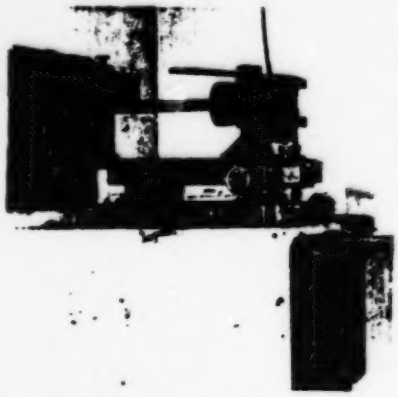


Fig. 1 - Complete universal receiver mounted on a concrete base.

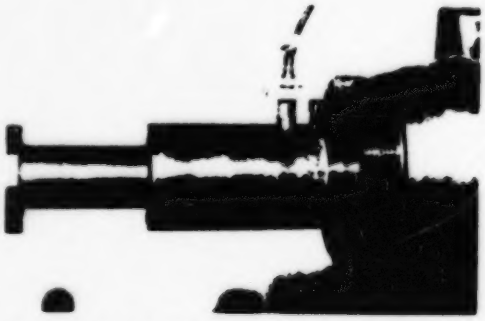


Fig. 2 - Typical barrel with pressure transducer.

The chamber pressure sensing transducer was of the conformal type (5) and located in the chamber area as dictated by the manufacturer. The pressure detecting face of this transducer conforms to the chamber surface. When a round is fired, the pressure is transmitted through the cartridge case to be detected by the transducer. The signal from the transducer is fed through an amplifier to a peak reading meter and a digital oscilloscope. Figure 3 shows the equipment used to record the chamber pressure and the bullet velocity.

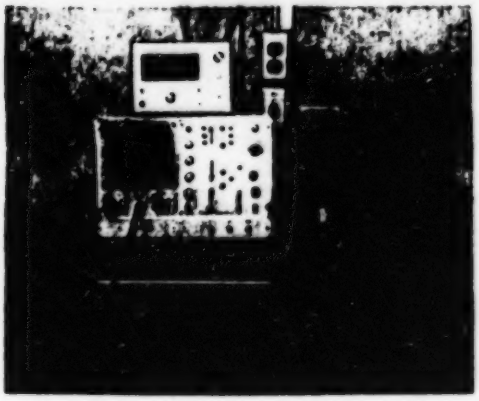
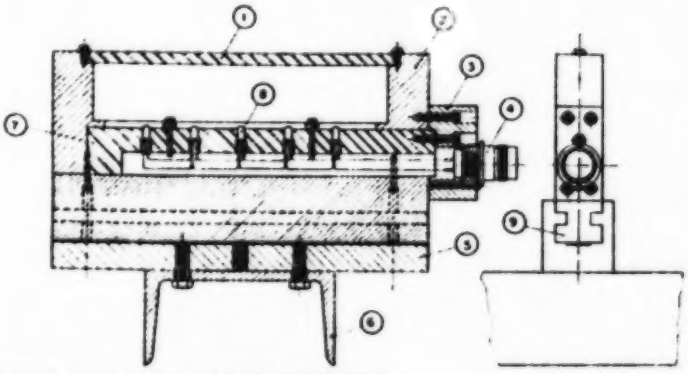


Fig. 3 - Equipment used to record chamber pressure and bullet velocity.

All of the above equipment is located in what is termed the instrument room in Building 14. The barrel of the gun is aimed in a steel pipe through the range wall. The pipe serves as a safety feature by ensuring continuity of the barrel into the range. A door on this wall also has a safety interlock that allows firing only when it is closed. This ensures the proper operation of the ventilation system in the range.

The range is a room 25 m long, 2 m wide, and 2.3 m high having a sand trap for catching bullets at one end. An air circulation system is designed to move the air from the instrument room end to the sand trap end. Such air movement draws the fumes away from the instrument room and prevents dust from interfering with the velocity measuring equipment.

The velocity of the bullets is determined using two detectors set at a fixed distance apart. Reference (6) describes this system in detail. Basically, the detectors are used to determine the transit time of the bullet over the fixed distance by starting and stopping a clock. Each detector is composed of a series of photoelectric transistors that are able to detect the shadow of a bullet passing over their line of sight. Figure 4 shows a cross-section of such a detector. Three electric bulbs, installed about 20 cm above the detectors, serve as the source of light for their operation. Figure 5 also shows heavy steel bullet deflectors that protect the detectors from stray projectiles. An aluminum channel with three sets of slots allows positioning of the sensors at a distance of one metre apart for testing shotshells and two meters apart for testing sporting ammunition. Figure 6 shows this system positioned in the shooting range in front of the universal receiver.



PROJECTILE DETECTOR PARTS LIST

1. Plastic window
2. Aluminum case
3. Aluminum block
4. Electrical connector
5. Brass base
6. Aluminum channel
7. Delrin detector holder
8. Detector (Q-ty 5)
9. Aluminum slide

Fig. 4 - Cross-section of bullet detectors.

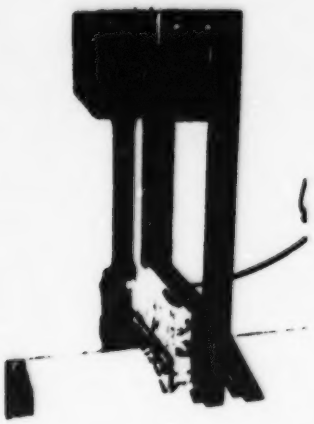


Fig. 5 - Bullet detectors positioned ahead of the bullet deflectors and underneath the light source.

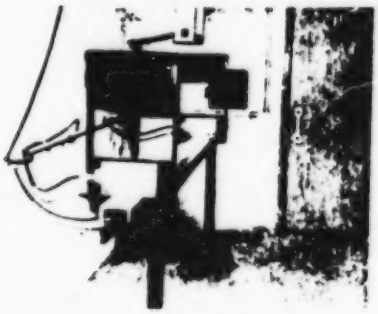


Fig. 6 - Velocity measuring system in the range.

The electronic instrumentation will automatically display the velocity of the bullets in the proper units. To do so requires setting the detector separation on the front panel of the instrument.

TEST PROCEDURE

Figure 7 shows the relative location of the test components at Building 14. The method and safety procedure followed for determining the chamber pressure and bullet velocity is detailed in reference (7). Basically, once the universal receiver is loaded and and the instrumentation is armed, the operator fires the gun from the remote location indicated. The velocity and the peak pressure are digitally displayed whereas the pressure profile is recorded on an oscilloscope. The pressure profiles are analysed for reproducibility and discrepancies.

A number of rounds are then fired to obtain statistically meaningful values of the velocity and peak pressure. These values and as reference, those published by SAAMI, are reported.

BIBLIOGRAPHY

1. Potter Instrument Company Inc., Great Neck, New York, U.S.A.

2. Technical Services Division of Energy, Mines and Resources, Ottawa, Canada.

3. Contestabile, E., T.R. Craig, and P. Larson, CERL's Projectile impact testing facility, Canadian Explosives Research Laboratory, ACEA/MRL 86-73(TR).

4. SAAMI, Sporting Arms and Ammunition Manufacturers' Institute, Inc. P.O. Box 256, Wallingford, Connecticut, 06492.

5. PCB Piezotronics, Inc., 3425 Walden Ave., Depew, New York, 14043-2495.

6. Nagy, E. and Contestabile, E., Apparatus for measuring the velocity of projectiles, Canadian Explosives Research Laboratory, ACEA/MRL 85-68(TR).

7. Craig, T.R., Sporting ammunition test procedure, Canadian Explosives Research Laboratory ACEA/M&MR, MRL 86-46(TR).

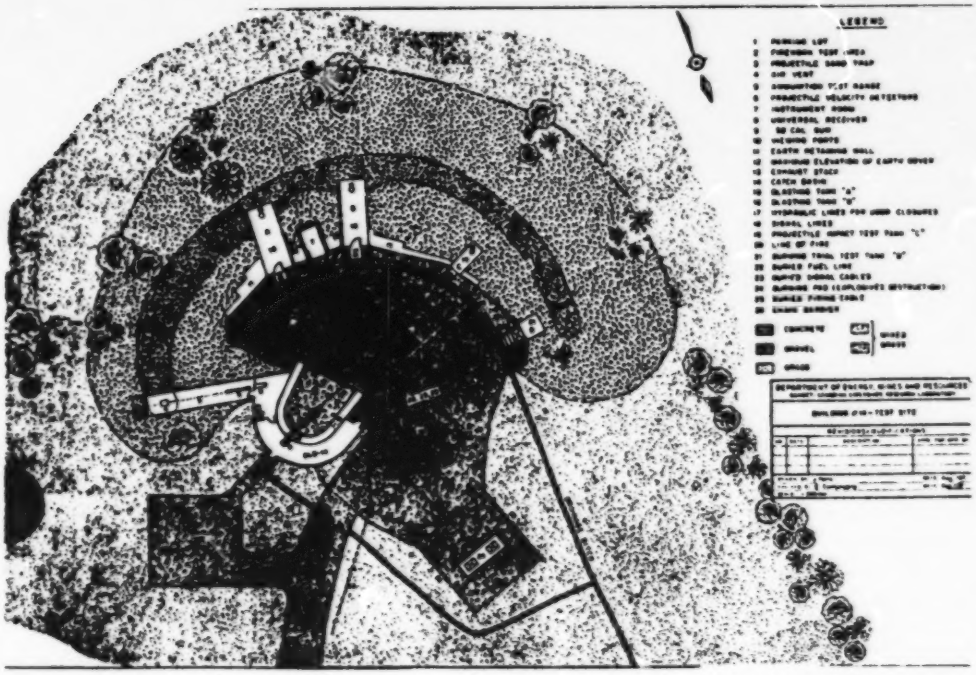


Fig. 7 - Location of test components.

UN TEST SERIES 4 (a)

This test is performed in Building 14 of CERL. What follows has been reproduced from the United Nation's "Recommendations on The Transport of Dangerous Goods, Tests and Criteria, First Edition".

INTRODUCTION

31.1 Series 4 tests are intended to determine the overall stability of the package or unpackaged article in environments which stimulate transport conditions other than fire to answer the question in Box 16, Fig. 1.2 (i.e., "Is the article, packaged article or packaged substance, too hazardous for transport?").

31.2 Typical transport conditions include high temperature and relative high humidity, low temperature, vibration, bumping and dropping. The tests are carried out on the packaged substance, packaged article(s) and, if intended to be transported unpackaged, on the article itself.

31.3 Type 4(a) test: This determines the thermal stability of the packaged substance, packaged article(s) or the unpackaged article. e.g., Test 4(a) Thermal Stability for articles and packages.

31.4 Type 4(b) tests: These determine the effect of dropping the explosives from heights of a few metres, simulating a fall from a vehicle, or up to 12 m, simulating a fall from a crane into the hold of a ship. e.g. Test 4(b)(i) The Steel Tube Drop Test for Liquids; Test

4(b)(ii) Twelve Metre Drop Test for Articles and Solid Substances

31.5 The question in Box 16 is answered "Yes" if a positive sign is obtained in either Test Type 4(a) or 4(b).

TEST 4(a)

THERMAL STABILITY TEST FOR ARTICLES AND PACKAGED ARTICLES

32.1 INTRODUCTION

This test is designed to evaluate the thermal stability of articles and packaged articles when subjected to elevated thermal conditions to determine whether the unit being tested is too hazardous for transport. Several criteria are used to evaluate the results of the test. This test does not apply to packaged substances. The minimum size unit acceptable for this test is the smallest packaged unit.

32.2 APPARATUS AND MATERIALS

This test requires an oven equipped with ventilation, explosion-proof electrical features and thermostatic control to maintain the temperature at 75 ± 0.5°C. It is desirable that the oven should have dual thermostats or similar protection against excessively high temperatures in the event of a thermostat malfunction. The oven must also be fitted with a temperature recorder to assess any exothermic temperature increase.

32.3 PROCEDURE

Depending on the unit being tested, a thermocouple is placed either:

on the outside casing of the unpackaged article, or on the outside casing of an article which is located near the centre of its package. The thermocouple is attached to a temperature recorder. The unit to be tested (together with the thermocouple) is placed in the oven, heated to 75°C and maintained at the temperature for 48 h. The unit is then removed from the oven, cooled and inspected. In dealing with an unknown article, proper precautions should be taken in carrying out the test. Temperatures are recorded and the visual examinations noted.

32.4 CRITERIA AND METHOD OF ASSESSING RESULTS

A test result is considered positive (+) if any of the following occurs:

a) It explodes
b) It ignites
c) It generates coloured fumes or odour
d) It experiences a temperature rise exceeding 3°C
e) The outside casing of the article or the outside packaging is damaged.

An article or packaged article(s) which gives a positive test result is judged to be too hazardous for transport.

BIBLIOGRAPHY

1. Recommendation on the Transport of Dangerous Goods, Tests and Criteria, First edition, United Nations, 1986, ISBN 92-1-139021-4.

THE ABEL HEAT TEST

This test is performed in the chemistry laboratory in Building 12 of CERL.

SCOPE

The Abel Heat Test is used to determine

the stability of propellants and explosives containing nitrate esters (i.e., nitroglycerine) and nitrocellulose.

PRINCIPLE

At 71°C, (in the case of cordite, 82°C), nitrate esters decompose and nitrogen dioxide evolves. On contact with a piece of potassium iodide/starch paper moistened with a 50% aqueous glycerol solution, a mixture of nitrous and nitric acid forms which causes discolouration at the border between the moistened and dry areas of the indicator paper.

The parameter measured is the time required to cause discolouration with longer times indicating greater stability of the substance under test.

SAFETY PRECAUTIONS

- Avoid skin contact when handling the sample
- Handle sample in fume hood
- Conduct experiment behind a safety shield

APPARATUS

- Electrically heated oil bath with a temperature controller (oil level should be 1 cm below the lid)
- Control thermometer
- Test tube: 14 mm to 17 mm diameter by 140 mm long, having a mark at the two cubic centimetre level
- A rubber stopper through which passes a 4 mm diameter glass rod that has a platinum hook fused to its lower end
- Test tube holder mounted across the bath and has six perforated sleeves which are 6 cm
- long Potassium Iodide/starch paper
- Glycerol
- Distilled water

DISPOSAL

- The sample is placed in a labelled, disposable paper container for destruction by burning at a scheduled time.

PROCEDURE

The sample size and test temperature are based on the material tested: 1.6 g of propellant or smokeless powder at 71°C or 1.6 g of cordite at 82°C or 3.5 g of gelatin dynamite mixed with 6.5 g of French Chalk at 71°C.

The following procedure applies to dynamites. In the case of the other samples, they are weighed directly in the test tube.

Weigh separately 3.5 g of dynamite and 6.5 g of French Chalk. Transfer the dynamite into a mortar and gradually add the French Chalk mixing with the pestle after each addition. When an homogeneous mixture is obtained, transfer it in small quantities to the test tube. Tap the test tube gently and press the composition with a flat-ended glass rod. Repeat this procedure until the tube is filled to a maximum height of 4.4 cm.

A 10 mm by 40 mm strip of potassium iodide/starch paper is pierced and moistened at the upper end with a drop of 1:1 mixture of glycerol and water. This paper is then hung on the platinum hook and lowered in the test tube so that its lower end is 5 cm above the surface of the sample. Figure 8 shows the set-up.

The test tube is then placed in the bath and a timer is initiated. When a light brown colouring occurs at the wet and dry interface on the paper, the timer is stopped. This time is recorded. If no discoloration occurs within 20 min, the experiment is terminated.

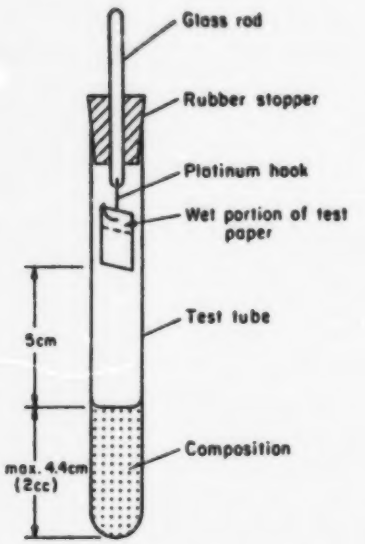


Fig. 8 - Test configuration for the Abel Heat Test.

BIBLIOGRAPHY

1. Urbanski, T., Chemistry and technology of explosives, Vol 2, Pergamon Press, New York, 1965.

2. Fedetoff, B.T., Encyclopedia of explosives and related items, Vol 1, Picatinny Arsenal, Dover, New Jersey, USA, 1960.

PRIMER HEAT TEST

This test is performed in Building 14 of CERL.

SCOPE

The test is used to determine the effect of a heat cycle on the functioning of ammunition primers.

PRINCIPLE

At elevated temperatures, it is possible to artificially age the primers to simulate the effect of prolonged storage.

SAFETY PRECAUTIONS

- follow safety precautions for obtaining primer samples
- always test primers in the pipe provided
- test primers at room temperature
- wear safety glasses
- allow pipe container to cool before opening

APPARATUS

- Temperature controlled oven
- Control thermometer
- 5 cm diameter by 20 cm long steel pipe threaded at both ends for two cast iron caps
- 24 h timer
- universal receiver or other appropriate gun

DISPOSAL

- The sample is either destroyed by functioning with the universal receiver or by placing it in a labelled container for disposal by burning at a scheduled time.

PROCEDURE

The power is switched on and the oven's temperature is allowed to stabilize at a 100°C.

A sample consisting of a minimum of two and a maximum of ten primers is carefully placed in the steel pipe container held in an horizontal position. The cap is then hand tightened on the container and placed in the oven. This time is recorded. The oven is also labelled to indicate that the experiment is in progress. Figure 9

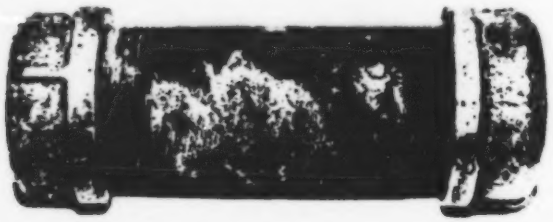


Fig. 9 - Pipe container for the Primer Heat Test.

shows the pipe container.

After twenty four hours, the power is switched off and with the oven door remaining closed, the temperature is allowed to return to that of ambient.

Remove the pipe container from the oven and take it to the test site. Remove the pipe cap and the primers with caution. With the primers still in the cartridge or shell, insert them in the corresponding barrel in the universal receiver and fire them.

The primers' proper function is indicated by a loud sound, smoke generation, and odour. In the case of no sound the test must be repeated. If the same result is obtained, the sample is deemed to have failed the test.

COMMUNICATION TEST

This test is performed in the horseshoe area of Building 14 of CERL.

SCOPE

The communication test is used to determine if the potential exists for a cartridge, functioned in its smallest container, to initiate any of the other surrounding cartridges.

PRINCIPLE

By initiating a cartridge, centrally located in a container, it is possible to determine if the danger exists of initiating the adjacent items.

SAFETY PRECAUTIONS

- Post sign indicating that testing is in progress
- Handle sample with care
- Turn power off before opening steel container
- After test be sure to remove all residue from sand

Apparatus

- Steel container with access for electrical wires, filled with sand, and having a spring loaded steel lid
- Wheeled trolley
- Variable power supply (variac) with 6 m of cable
- 25 cm, gauge Nichrome wire
- High temperature cement (i.e., muffler or stove cement)
- Scoop and pail
- Masking tape

DISPOSAL

- The sample is placed in a labelled disposable paper container for disposal by burning at a scheduled time.

PROCEDURE

Assemble a heater by forming a small coil with the Nichrome wire. Then, using high temperature cement, fasten it against the base of the primer (of the item) to be tested. Such an assembly is shown in Fig. 10. Centrally locate this item in the box provided by pressing the heater wire through one side of the container. Next, place the remaining items in the box; close the box and tape it if necessary. The sample is now ready for placement in the steel container.

Fig. 10 - Sample with initiating heater coil installed.

Using the trolley, move the steel container to the centre of the horseshoe area of Building 14 and unlock and open the lid. With the scoop remove sufficient sand to allow positioning of the sample in the centre of the container. This is shown in Fig. 11. Connect the heater to the incoming wires, and return the sand to completely cover the sample. Close and lock the lid of the container ensuring that the steel springs are slightly loaded.

Fig. 11 - Sample placed in the communication test container.

Connect the electrical cable to the terminals on the container and to the variac which is located inside Building 14. Ensure that the variac is set to zero output and plug it into an AC receptacle. Connect the firing cable to the variac. The event can be observed from the glass covered viewing port. Slowly increase the voltage and listen for any sound that may be heard or look for any smoke that would indicate the functioning of the item. In the case that no such indicators are witnessed, fire again. When an event occurs, wait thirty minutes before approaching the container.

The sample fails the test if any of the surrounding items are initiated.